

# A Review on Numerical Simulation and Comparison of Carbide and HSS Tool Wear Rate while Drilling with Difficult To Cut Super Alloy Titanium Based on Archard Model

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**Abstract**— A Carbide and HSS tool wear rate simulation using Archard's wear model is proposed, finite element modelling is done using commercial finite element software ABAQUS/explicit. ABAQUS interface was used to simulate the contact pressure. For measuring wear depth of tool's drilling operation is performed experimentally then wear depth is measured on profilprojecter. Comparing the wear rate, based on Archard model.

**Keywords**— Finite Element Analysis, Titanium Drilling, Archard's Model, Wear Rate, Carbide and HSS Tool.

## I. INTRODUCTION

Titanium alloys are used extensively in aerospace, automobile and medical application because of combined high special strength (strength-to-weight ratio), fracture-resistant characteristics and exceptional resistance to corrosion. However, titanium alloys are usually considered as extremely difficult to cut material because of their low thermal conductivity and high chemical reactivity with cutting tool materials. Tool wear is major issue in dealing with titanium.

Being one of the new hole-machining methodologies, drilling is widely used machining process, which account for 40-60% of total material removal process. In the past, lot of experiments need to be conducted to obtain a series of related data during the drilling studies, which bring about huge raw material consumption. Finite Element simulation can not only save the raw material but also improves accuracy of result. Furthermore, finite element analysis can also obtain the measured data which is difficult to obtain in experiment.

## II. OBJECTIVE

The objective of this review paper is to discuss the finite element modeling when drilling with Ti6Al4V alloy and use of FEM software.

## III. PROPERTIES OF MATERIAL

Table.1: Material Properties.

| Material properties parameters | Ti6Al4V         | Carbide         | HSS             |
|--------------------------------|-----------------|-----------------|-----------------|
| Density (kg/m <sup>3</sup> )   | 4420            | 1570            | 8140            |
| Young modulus (Pascal)         | 122,000,000,000 | 669,000,000,000 | 207,000,000,000 |
| Poisson ratio                  | 0.31            | 0.26            | 0.27            |

## IV. FINITE ELEMENT MODELING

In the area of engineering and mathematical physics Finite element modeling is used to finding out the problems. The area on which attention focuses on distribution of stress, temperature, strain, displacement, contact pressure etc. The FEM have different models using them the actual working condition is developed. The FEM gives such a result which is difficult to obtain in actual.

## V. WEAR MODEL

Tool wear is major issue in production process which can be minimized up to some extent by selection of correct tool at appropriate process parameter. For predicting wear rate Archard's wear law is most commonly used which is expressed as [5]:

$$k_D = V / F_N \cdot s \quad (1)$$

Where  $k_D$  dimensional wear rate.  $V$  is the wear volume,  $F_N$  is the normal load,  $s$  is the sliding distance.

## VI. LITERATURE REVIEW

Ozden Isbilira, has done the analysis for drilling of titanium alloy, the drilling tests are performed for determining the efficiency of FE model. The thrust force, torque, burr height is measured experimentally and compared with FE results for validation. The study shows that the FE model of drilling can be used as for predicting the changes in cutting force, torque and stresses with respect to drilling process parameters [4].

Xuejin Shen, has done the simulation for determining the sliding wear rate using Archard wear law. He has done the finite element modeling for predicting the wear of mechanical component. The geometry update and remeshing are taken into account in order to obtain the accurate result [5].

Yong Yang, Jie Sun introduced simulation for drilling of titanium alloy, a three-dimensional finite element model of drilling process is developed. Prediction of cutting force and comparison with experimental values are done. Study shows that finite element model is reasonable. The stresses and temperature in drilling process at initial condition increases up to its maximum value when process comes at its steady state then gradually decreases. Optimal process parameter for drilling can be determined using FEM [6].

Y. Su, D.D. Chen, L. Gong has described 3D Analysis of drilling for Ti6Al4V Alloy, using commercial finite element software DEFORM 3D. Analysis is done at different process parameters for investigating the influence of process parameters on performance of machining. The study shows that FE model can be recommended for predicting optimal process parameter for drilling of Ti6Al4V [7].

Viorel Petrariu, Dumitru Amarandei, Stelian Alaci studied about Finite element analysis of high speed drilling. The attention focused on advantages of software used for simulation of cutting process. Their study showed that FEM can be used to obtain the optimum process parameters, the expensive trial and error method can be eliminated [8].

A. Attanasio, F. Fainia and J.C. Outeirob has investigated the tool wear when drilling of Inconel 718, using FEM. The tool geometry update is implemented in FEM. Investigation showed that a good agreement was obtained between the predicted and measured tool wear data [9].

Robson Cristiano Brzostek, Jose Antonio Esmerio Mazzaferro, Jorge Fernandes dos santos, Telmo Roberto

Strohaecker has, studied development of the computer model of Johnson-cook damage criterion for friction spot welding. They have developed Johnson-Cook damage criterion model for crack initiation, coalescence and the final fracture. AA 2024-T351 and clad AA 2024-T351 aluminum alloys is used as based material. The numerical model results obtained shown good agreement with the experimental tests [10].

John M. Thomson, Mary Kathryn described, a proposal for the calculation of wear based on Archard model using FEM. In the structural analysis the effect of wear is included. Wear strain is calculated using Archard model. In order to modify the elastic strain in element [11].

M. Kolahdoozan, F. Azimifar, S. Rismani Yazdi investigated tool wear for drilling of nickel and analysis is done for optimization of tool wear using response surface methodology. The study deals with monitoring tool wear through the chip formations, forces, and edge temperature of drill while drilling in super alloy plate to optimize effective parameters which lead to facilitate machining process to improve tool life, and enhance productivity. Inconel 718 super alloy material and cemented coated carbide tool have selected in their study to investigate tool wear mechanism. Mathematical models were deduced by Minitab software to display the effect of the main process parameter such as cutting speed, feed rate and tool diameter on tool wear. A wear is predicted using finite element method, a 3D model of twist drill is developed, wear is compared experimentally the result recorded 95% confidence and verified by ANOVA. The simulation results were in accordance with experimental and predictive values from RSM with error rate of 4-6%, proving the ability of the tool wear model to correctly forecast it. Also the experimental results showed that cutting speed as the main parameter followed by feed rate, contribute significantly the tool wear of drill bit [12].

Hemant S. Patne, Ankit Kumar, Shyamprasad Karagadde and Suhas S. Joshi proposed the distribution of temperature while drilling of titanium work piece. They have divided the cutting edge of tool into series of independent elementary cutting tools (ECT). The cutting forces are simulated and then evaluated the distribution of temperature with consideration of heat partition factor. Also the results are validated experimentally using IR camera, simulation results are in accordance with the experimental result [13].

A.M. Abdelhafeeza, S.L. Soo, D.K. Aspinwall, A. Dowson, D. Arnold investigated, hole quality and formation of burr while drilling with aluminium and titanium alloys. Investigation shows that the interaction of

cutting speed and feed rate is statistically significant while drilling titanium and flank wear of tool is less than 30 $\mu$ m (after 60 holes) in all tests [14].

## VII. PROPOSED WORK

FEM can be used for predicting the stress and temperature distribution in drilling process which is quite difficult with the actual experimental setup. From this review paper it is seen that the contact pressure distribution in drilling process can be studied and compared which would be able to predict the wear rate of cutting tool.

## VIII. CONCLUSION

From the recent studies for simulation of drilling process it is seen that FEM has very precise accuracy of result. The FE cutting Simulation gives good results under the boundary conditions. Which save the time and cost of manufacturing.

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